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IMPROVING THE ENVIRONMENTAL PERFORMANCES OF IRON POWDERS CARBURIZING PROCESS IN A METHANE-BEARING ATMOSPHERE

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Abstract

Considering the advantages of steel surface hardening, when less expensive low- and medium- carbon steels can be surface hardened without the problems of distortion and cracking associated with the through hardening of thick sections, we developed some research entailing the increase in environmental performance of iron powders carburizing process using methane as carrier. Apart of studies on optimal working parameters and methods, our research addresses improvements in environmental performance of process by selecting powders suppliers, reducing raw materials and energy consumptions, considering products life cycle analysis. A comparison is also performed among the characteristics of three series of research for obtaining ecological steels for automotive industry.

Key words: carburizing, environmental performance, LCA, sintering, steel

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1. Introduction

In the contemporary society, industries should consider environment as a major issue, which impacts the ecological systems on both for existing and future generations due to unsustainable company's activities (Azevedo, 2013; Peiró-Signes et al., 2011; von Gleich et al., 2007).

Environmental aspects became important for decision making besides other such as economical, political etc. However, the lack of knowledge about the ecological effects of industrial activities and especially complexity in quantifying these effects stand for a current problem (Carlig et al., 2008; Copelli et al., 2013; OECD, 1999; Zaharia, 2011). Numerous companies and organizations involved in activities developed assessment systems according to ISO 14000.

Powder metallurgy (PM) represents a sum of innovative processes whose aim is to obtain advanced materials or improved properties comparative to those obtained through classic procedures (Guinee, 2002; Liu et al., 2011). As shown by the statistics, the development perspectives of the production of parts elaborated through procedures that are specific to powder metallurgy are positive even in current days of economic crisis (Alcorta and Nixson, 2011; Fang and Sun, 2012; Torralba et al., 2913). The global sales of powder metallurgy (PM) components are expected in 2012 with an average annual growth rate of 5% (http://www.powdermetallurgymarket.com/).

The *Advanced Engineering Group* of the Department of *Engineering and Management of the Technological Systems*, Drobeta Turnu Severin, within the University of Craiova - Faculty of Mechanics, addresses the improvement of steels

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manufacturing process performance by applying the carburizing of the metallic iron sample in methane environment as one of the main research directions.

The paper analyses the results of research addressing carbon enrichment of metallic iron samples by carburizing in methane environment, which should led to results that can be reproduced so as the research be extended to obtain components able to be used in the automotive industry. These materials are intensely studied because they should answer to quality demands concerning chemical corrosion complex mechanical tests.

2. Case-study on carburizing processes of iron powders

As mentioned above, the scope of the research concerned the elaboration of a new procedure to obtain sintered carbon steels using metallic iron powders as raw material, which are enriched in carbon due to the contribution of carbon from the methane gas, during the sintering process in methane atmosphere.

In parallel with the basic direction, the emphasis has also been put on the growth of the environmental performance of this procedure.

2.1. Saving raw materials

The development of new PM technologies is an important way to save raw materials. Various components obtained through PM can ensure a high efficiency in the utilization of raw materials of 98-99%. The main raw material is the iron powder with high purity. The first research, which started in 2005, used iron powders bought from the company POMETON – Italy, which has been competitive due to the quality – cost ratio. The good results that have been obtained have led to an increased use of iron powder.

2.2. Selection of suppliers

As a consequence of the increasing in the quantity of iron powder used in PM process, the offer became much diversified, so that a selection of the potential suppliers was necessary based on a number of criteria, such as: costs; quality; the existence of implemented systems for environmental and quality management; the distance from the providers.

The list of suppliers comprises:

1. GKN Hoeganaes Corporation Europe S.A. Buzău, Romania
2. GKN Hoeganaes – Huckeswagen, Germany
3. Pometon Powder- Venice, Italy

Even though produced high quality powders, the company POMETON Powders achieved the Environmental Management System Certification according to ISO 14001: 2004 and the Occupational Health & Safety Management System Certification according to BS OHSAS 18001:2007 on July 14th, 012. This is why the company was accepted on the list of the suppliers in the second half of 2012.

Another company, Hoeganas became attractive due to several relevant characteristics, such as:

a) favorable quality – cost ratio;
b) certification of integrated quality, environment and health management system;

ISO/TS 16949 is an international standard striving for the development of a Quality Management System that provides circumstances for continual improvement, stressing the prevention of failings and reducing variation and waste in the supply chain. The International Organization of Standards has developed TS 16949 based on ISO 9001. ISO 14001 is another internationally recognized standard used by organizations to design and execute an effective environmental management system, considering also the impacts generated by a product or process during its life cycle. OHSAS 18001 is a standard used to promote a safe working environment. The company has been selected after the environmental commitment has been analyzed, which showed that Höganäs AB products are based on efficient energetic and ecologic solutions for its customers. The production processes are characterized by efficient use of natural resources and energy, concomitantly with minimum waste generation. The objectives related to environmental and energy issues and also the action plans are based on ISO 14001 standards for environmental management. For example, completely recyclable packages minimize the costs of transport and the impact on the environment.

c) technical support in the laboratories of the company;
d) the distance from the supplier.

2.3. Saving electrical energy

The first series of research (I) entailed establishing of the optimum parameters of carburizing – sintering process. The study was developed following the cyclogram illustrated in Fig. 1 (Ghermec et al., 2009). The heating phase (800-900^{o}C) takes place in a thermo resistant oven. The duration of heating, which determines how much energy is consumed, varies between 540 and 780 minutes, the difference being in maintaining time at the carburizing temperature of 910^{o}C. During the heating and until this temperature, bearing of 5 minutes were supported to every 100^{o}C added to the temperature. Another variable has been the sintering temperature which has taken place at 1050, 1100, respectively 1150^{o}C.

The second series of research (II) (Fig. 2) took place at sintering temperatures of 1150^{o}C, with the application of a debinding bearing at 350^{o}C and maintaining for 30 or 60 minutes at the carburizing temperature, followed by 60 minutes of sintering (Ghercioiu, 2011). The heating time has thus decreased to 392 minutes. The third series of research

(III) (Fig. 3) consisted of changing the succession of the operations: in the first phase there was sintering at the temperature of 1150°C followed by carburizing at 910°C. The cyclograms are given in Fig. 3. The consumption of electrical energy is the most consistent in the phase of temperature increasing up to 1150°C and maintaining at this sintering bearing for 60 minutes. Then the oven is stopped for cooling until 910°C and then electric energy is consumed only to maintain the temperature constant. The heating time is of 340, respectively 370 minutes.

3. Results and discussion

3.1. Minimum quantity of waste

The pieces obtained through the three procedures described above can have complex configurations with a very good dimensional accuracy. This is why the degree of using iron powders is 99%. The losses in material as waste appear only in the phase of pressing in mold and are very low.

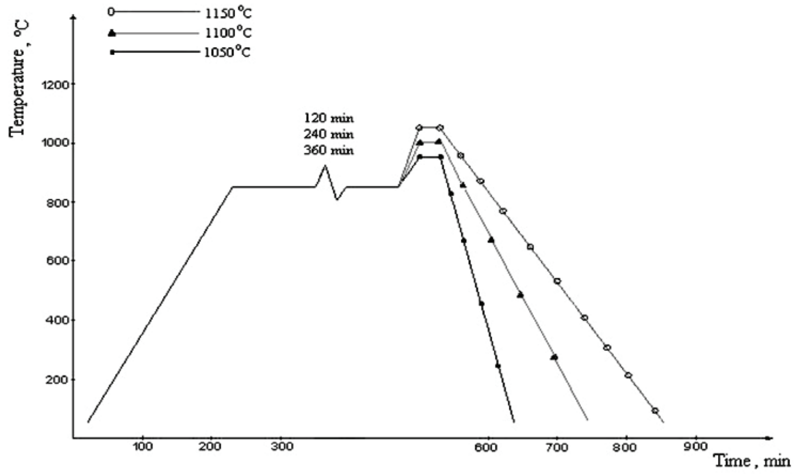

Fig. 1. The carburizing – sintering treatment cyclograms for series I

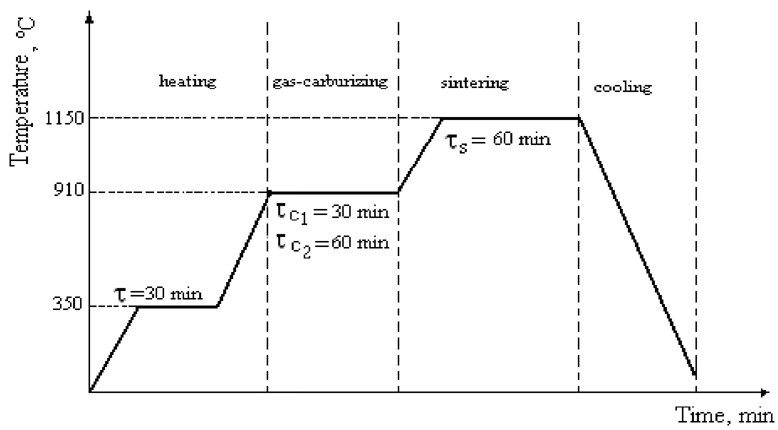

Fig. 2. The carburizing – sintering treatment cyclograms for series II

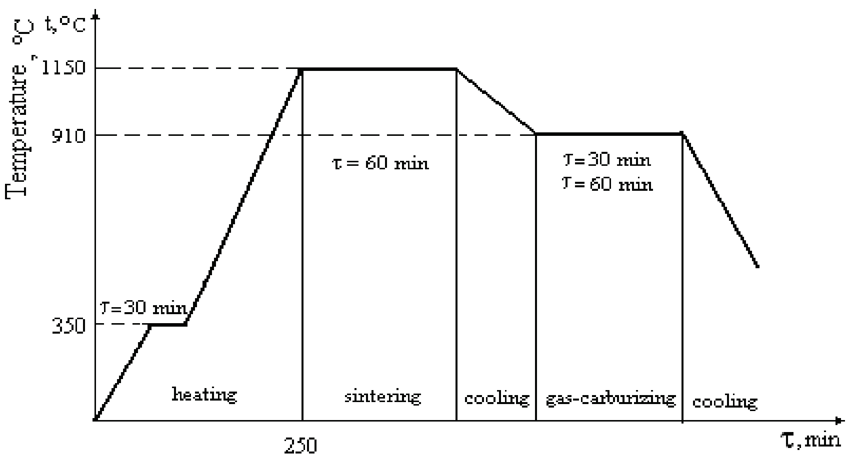

Fig. 3. The cyclograms for series III

The waste can be recycled. Obtaining the steel through carbon enrichment of the iron powder in methane gas medium is not accompanied by solid waste or wastewaters. The packages in which the metallic powder is supplied can be recycled.

3.2. Life cycle characterization

The study of the life cycle of the process of carburizing of the iron powders is methane gas medium shows that the phases the raw material goes through until the final product are in a significantly reduced number from the classic technologies used to obtain steel. The procedure can be extended at the level of series or mass production allowing the automation and the driving assisted by computer.

The procedures specific to PM can ensure the final shape of the part even from the pressing phase in the mold; the phases of surface manufacturing, which consume a lot of energy and produce waste which needs to be recycled, are eliminated. Also, the molds are made of recyclable materials. Carburizing – sintering takes place in a carburizing box which is used at a large number of processes and is also recyclable.

Considering the technical and structural properties which characterize them, the parts obtained through carburizing – sintering are suitable for the eco – design of the products they are to be assembled in. The configurations of these parts can have complex forms so that they can replace a large number of simple parts in the mechanic system and can also take their functions. There are thus saved raw materials, energy to manufacture, decreased emissions in air and water, as well as in the quantity of waste. The parts can be easily disassembled in order to maintain them.

The eco-design increases the environmental performance of the producers simultaneously with the improvement in quality and the maximization of benefits (Velicu et al., 2009). The steels resulted through the process of carburizing- sintering show a lower density than the steel obtained through classic processes.

In comparison to the density of the classic steel, which is of 7.85 g/cm^3, the density of the parts elaborated through the new procedure has values between 7.2 -7.4 g/cm^3. In this context, the mass of parts obtained through specific procedures of powder metallurgy is reduced from the classic one. In the automobile industry, a lower mass represents an advantage because the efficiency of the use of fuel for travel grows.

The steels used through the carburizing – sintering alternatives described above can be considered as **ecologic**. This label brings some advantages to producers and users of these products: it improves the market and the society position and, by translating them in innovative organization, it is offered the chance for surviving and development (Negoescu et al., 2009).

3.3. Saving electrical energy

The economy of energy is shown in Fig. 4. The modification of the degree of heating and the reduction in the carburizing – sintering time has led to significant energy savings.

Due to the fact that, by classic heating, in a thermo resistant oven, it can not be increased the economy of energy without affecting the quality of the products, the research will continue in the direction of carburizing at the same time with microwave sintering.

4. Conclusions

The elaboration of a new procedure to obtain sintered carbon steels using metallic iron powders as raw material allows for saving raw materials and electricity, waste minimization and a good cost-efficiency ratio.

The innovative procedures applied to obtain sintered steels by methane gad carburizing of the iron sample can be conducted so that it can become "environmental friendly".

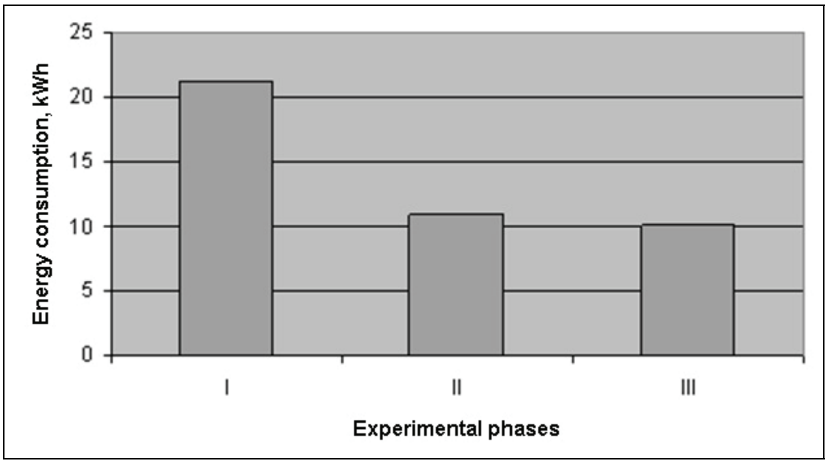

Fig. 4. The evolution of energy consumption in the process of carburizing – sintering (I, II, III – series of research)

The adequate selection of the suppliers of raw materials, the decrease in raw materials and energy consumptions and also the interest in the life cycle of the ecologic steels lead to an increase in the environmental performances of the PM process.

References

Alcorta L., Nixson F., (2011), *The Global Financial Crisis and the Developing World: Impact on and Implications for the Manufacturing Sector*, UNIDO, Vienna, On line at: http://www.unido.org/fileadmin/media/documents/pdf/Publications/110905/WP062010_Ebook.pdf.

Azevedo A., (Ed.), (2013), *Advances in Sustainable and Competitive Manufacturing System,* 23rd International Conference on Flexible Automation and Intelligent Manufacturing, Vol. 1, Springer, Cham, Heidelberg, New York, Dordrecht, London.

Cârlig E.D., Robu B., Macoveanu M., (2008), Quantification of environmental impact and risk induced by industrial activities on ground water quality: case study Cordun - Roman area, Romania, *Environmental Engineering and Management Journal*, **7**, 791-803.

Copelli S., Storti G., Torretta V., Derudi M., Sala Cattaneo C., Rota R., (2013), Detailed modeling of an industrial process: vinyl acetate emulsion homopolymerization, *Chemical Engineering Transactions*, **32**, 775-780.

Fang Z.Z., Sun P., (2012), Pathways to optimize performance/cost ratio of powder metallurgy titanium – a perspective, *Key Engineering Materials*, **520**, 15-23.

Ghercioiu J., (2011), *Research on elaboration of hybrid sintered steels with applications in manufacturing wear resistant parts*, PhD Thesis, University of Craiova, Romania.

Ghermec O., Ghermec C., Popescu T., (2009), A new technology to obtain ecological steel, *Environmental Engineering and Management Journal*, **8**, 1141 – 1144.

Guinee J.B., (2002), *Handbook on Life Cycle Assessment Operational Guide to the ISO Standards*, Springer - Kluwer Academic Publishers.

Liu M., Li W., Cheng Q., He Y., Cao X., (2011), Life cycle assessment for carbon emission of plate glass industry, *Environmental Engineering and Management Journal*, **10**, 739-742.

Negoescu F., Axinte E., Nagîţ Gh., Iosub A. (2009), Innovative solutions creates environmental advantages, *Environmental Engineering and Management Journal*, **8**, 1191 – 1197.

OECD, (1999), *Indicators of Industrial Activity: Sources and Methods, Quantitative Indicators*, OECD Publishing, Paris.

Peiró-Signes A., Segarra-Oña M., Miret-Pastor L., Verma R., (2011), Eco-innovation attitude and industry's technological level - an important key for promoting efficient vertical policies, *Environmental Engineering and Management Journal*, **10,** 1893-1901.

Torralba J.M., Fuentes-Pacheco L., García-Rodríguez N., Campos M., (2013), Development of high performance powder metallurgy steels by high-energy milling, *Advanced Powder Technology*, **24**, 813–817.

Velicu St., Corăbieru P., Zaiţ D., Corăbieru A., Vasilescu D.D., (2009), Alignment of the manufacturing technologies of automotive metallic component, to the environment European directives, *Environmental Engineering and Management Journal*, **8**, 1185-1190.

von Gleich A., Ayres R.U., Gössling-Reisemann S., (Eds.), (2007), *Sustainable Metals Management: Securing Our Future - Steps Towards a Closed Loop Economy*, Dordrecht.

Zaharia C., (2011), Assessing the impact of some industrial and transport activities on soil by the global pollution index, *Environmental Engineering and Management Journal*, **10**, 387-391.